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REPORT OF THE ACTIVITIES OF THE SUB-COMMITTEE ON THE DEVELOPMENT AND/OR STANDARIZATION OF METHODS FOR THE STERILIZATION OF BEDDING, BEDDING MATERIALS AND UPHOLSTERED FURNITURE FOR 1951

Public Health Service
Cincinnati, Ohio

1951

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REPORT OF THE ACTIVITIES OF THE SUBCOMMITTEE ON THE DEVELOPMENT AND/OR STANDARDIZATION OF METHODS FOR THE STERILIZATION OF BEDDING, BEDDING MATERIALS AND UPHOLSTERED FURNITURE

For the past several years, the Subcommittee on the development and/or standardization of methods for the sterilization of bedding, bedding materials and upholstered furniture formerly under the direction of Dr. Roy Schneiter, * Chairman, has attempted to formulate a number of safe, effective, and economic methods for the sterilization of bedding materials and upholstered furniture requiring such treatment. Although the initial activities of the Subcommittee were confined to administrative work, one of the first observations noted by the Subcommittee was the number of variations and apparent ineffectiveness of many of the sterilization methods used at the present time, as well as a wide diversity of processing regulations promulgated by State and city health departments. It was on this basis that the Subcommittee felt the need for some experimental processing studies and collaborative tests with existing or proposed sterilizing methods before any standardization could be accomplished. Little if any actual experimental work was conducted however, until the summer of 1951 when the Division of Industrial Hygiene, U. S. Public Health Service, was transferred to Cincinnati, Ohio. At that time the Subcommittee was reorganized and plans were made to start a series of actual field surveys and experimental studies.

* Deceased

With the cooperation of Mr. Herman G. Porter, Chief, Sanitary Bedding Section, Division of Weights and Measures, Indiana State Board of Health, plans were made to survey a number of installations in the vicinity of Indianapolis, Indiana, where used bedding and bedding materials were sterilized by several different processes. Two surveys were made which included a preliminary one in May, 1951, and a second conducted during the latter part of July, 1951, which included a number of bacteriological tests to determine the efficiency of each type of sterilization method.

Following the temporary completion of the field studies, a report of the results together with recommendations for future work was requested by the National Association of Bedding and Upholstery Law Enforcement Officials. This report was presented before the Bedding Law Enforcement Officials' annual meeting held on November 14, 1951, in Chicago, Illinois. The following is a summary of the above-mentioned report.

Field Survey No. I

The first study was primarily a preliminary survey to observe the current types of installations and the sterilization processes in operation. The plants visited included one in Madison, Indiana, where dry heat was employed as a sterilizing agent, another in Muncie, Indiana, where formaldehyde was used, and the Goodwill Industries plant in Indianapolis, Indiana, where a chamber had been installed in which such gases as methyl bromide, ethylene oxide, and Carboxide could be employed as sterilizing

agents. This particular sterilization process, however, was not in operation at the time of the visit.

At the Muncie plant a formaldehyde-permanganate mixture was employed as the sterilizing agent. This mixture consisted of 10 oz. formaldehyde (based on 1.0 pint/1000 cu. ft.*) and 5 oz. potassium permanganate. A few preliminary bacteriologic tests were conducted at this plant.

The chamber in this plant was built of wood and sealed with a commercial sealing compound. The chamber measured 7 ft. x 8 ft. x 12 ft., and contained a wooden built-in rack. A heavy ply-wood door without hinges was held in place by metal bars and wooden wedges. There was an air vent in the top of the chamber. The vent was operated by turning a windlass located on the vent shaft.

The bacteriologic tests were performed in the following manner. Pieces of Whatman No. 3 filter paper were cut into strips measuring two and three-quarter inches by one-half inch, sterilized in glass tubes, and placed in sterile petri dishes. Tryptose-phosphate broth ** was inoculated with the following species of bacteria: (1) Staphylococcus aureus,

* Indiana State Law.

** Tryptose-phosphate broth: Bacto-tryptose, 20 gm.; bacto-dextrose, 2 gm.; NaCl, 5 gm.; disodium phosphate, 2.5 gm.; distilled water, 1000 ml.

(2) Staphylococcus albus, (3) Aerobacter cloacae, (4) Escherichia coli, and, (5) Serratia marcescens, and incubated at 37° C. for 24 hours. Following the incubation period, 0.5 ml. of each bacterial culture was seeded onto the sterile strips of filter paper. The petri dishes containing the strips were held at room temperature until the strips were dry. The strips were then asceptically placed in sterile paper envelopes (two and three-quarters inches x one and three-quarters inches) which in turn were labeled according to the bacterial species on the strip, and placed in sterile, screw-cap, glass jars which were also labeled. The actual test consisted of asceptically placing the sterile envelope inside the sterilizing chamber as follows: (1) under the seat of a divan, (2) under the seat of an upholstered chair, and, (3) on top of a mattress lying on the rack.

The exposure period was for fifteen hours after which time the formaldehyde was removed from the chamber by opening the chamber vent for two or three hours. The door of the chamber was then opened, and the paper envelopes containing the strips of filter paper were asceptically replaced in their respective glass jars. On return to the laboratory, the exposed filter paper strips were removed from the envelopes and dropped in tubes of tryptose-phosphate broth. The tubes were then incubated at 37°C. for four days. All tubes showing growth during this incubation time were examined by microscopic procedures to determine whether the growth was due to the original bacterial organisms or to contamination.

Following the incubation of the exposed filter paper strips, all tubes contained the growth of the original test organisms. No residual bacteriostatic effect of formaldehyde was observed. These findings indicate the inefficiency of formaldehyde in the concentrations employed as a sterilizing agent when applied in a chamber held at atmospheric pressure. Indications also point to the lack of penetration of the formaldehyde gas into and through the various articles of furniture employed in the test.

Field Survey No. II

As a result of this preliminary study and further discussions with Mr. Porter, a series of more comprehensive bacteriologic control tests were planned in order to study fully the efficiency of the sterilizing agents employed by the various plants. A second field survey was arranged and conducted during the latter part of July, 1951. Arrangements were also made to have as many as possible of the members of the Subcommittee present.

The majority of the tests were made at the Goodwill Industries plant in Indianapolis, Indiana. In addition to Dr. Schneiter and the writer, the following members of the Subcommittee were present:

Mr. H. G. Porter
Chief, Sanitary Bedding Section
Division of Weights and Measures
Indiana State Board of Health
Indianapolis 7, Indiana

Mr. John J. Perkins
Director of Research
American Sterilizer Co.
Erie, Pennsylvania

Mr. O.N. Auer
President
Dacona Associates
P.O. Box 123
Glen Ridge, New Jersey

Dr. Robert Hegman
Safegard Inc.
930 York Street
Station B, Box No. 66
Cincinnati 22, Ohio

The objective of the second survey in Madison was to test the effectiveness of dry heat as a sterilizing agent. In addition to dry heat per se, dry heat and formaldehyde gas in combination were tested as sterilizing agents. The dry heat and formaldehyde test consisted of pouring one pound of 37% formaldehyde into a shallow pan, and placing the pan on top of one of the radiators inside the chamber (7' x 8'6" x 6-1/2') just before the introduction of the heat into the radiators.

In addition to the bacteriologic tests, temperature determinations inside the chamber were conducted in order to determine whether the temperature actually reached 230° F. according to the Indiana State Law. The time required to reach this temperature, and the time required for the heat to penetrate the mattresses which had been placed in the chamber were also investigated. To accomplish this, thermocouples attached to long, lead-wires, which in turn were attached to a battery-operated, temperature recording unit, were pinned to a number of mattresses in various locations. The mattresses which had previously been placed on a cart were then rolled into the chamber, and the doors of the chamber sealed on the thermocouple wires. The temperature-recording unit was placed outside the chamber from which readings were taken at three minute intervals for the dry heat test, and at 10 minute time intervals for the dry heat and formaldehyde test. The locations at which the thermocouples

were placed included:

1. On top of the top mattress.
2. Inside a cotton-felt pillow which was zippered shut.
3. Fastened to the middle mattress in the cart.
4. Fastened to the bottom mattress in the cart.

In addition to the temperature readings recorded from the thermocouple unit, readings were also obtained from the thermometer control chart which was attached to the outside of the chamber as prescribed by Indiana State law.

The bacteriologic tests were conducted simultaneously with the temperature recording tests. The test organisms employed included: (1) Staphylococcus aureus, (2) Serratia marcescens, (3) Escherichia coli, (4) Aerobacter cloacae, (5) Bacillus cereus, and, (6) Lycobacterium phlei. Strips of filter paper seeded with these organisms were placed in various locations on the cart containing the mattresses. These locations included: (1) The top mattress near the front of the cart, (2) The middle mattress, (3) The bottom mattress near the back end of the cart, and, (4) Inside a zippered cotton-felt pillow. Following each exposure period, which ranged from one hour and 15 minutes to two hours, the envelopes containing the strips of filter paper were removed and placed in sterile glass jars, and sent to the Indiana State Board of Health Laboratory. The filter paper strips were asceptically removed from the envelopes, placed in tubes of tryptone-phosphate broth and incubated at 37° C. for a maximum of two weeks. All tubes showing growth within this time were examined. Lack of growth in the subculture tubes indicated that the bacteria in the exposed

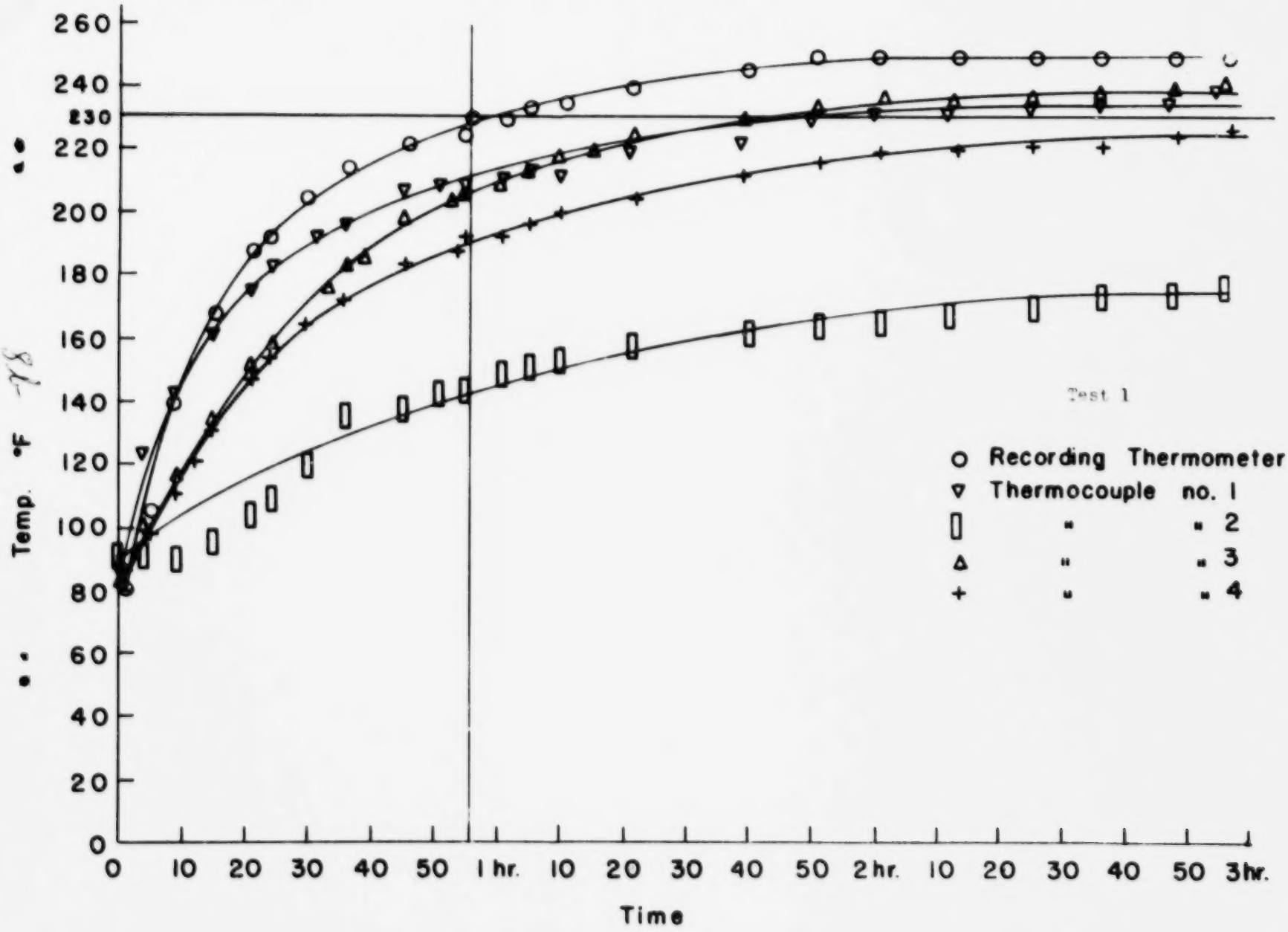
strips had been killed by the particular sterilizing agent employed.

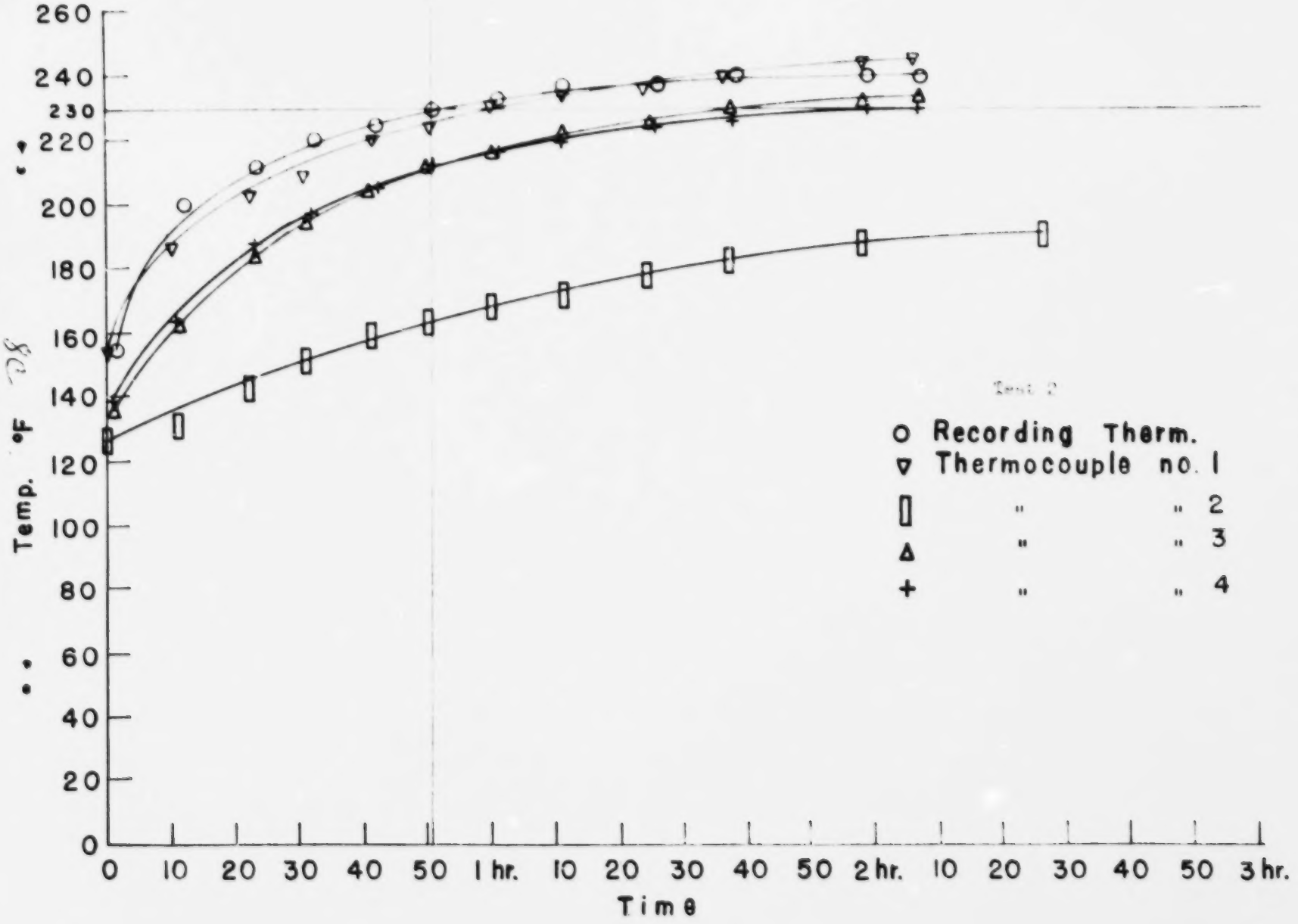
The results of the temperature-recording tests are shown in the graphs entitled Test I and Test II, "Rate of Temperature Rise at Various Locations Inside Chamber in Relation to that of Recording Thermometer".

In Test I, where dry heat alone was used, the recording thermometer attached to thechamber reached 230° F. in 56 minutes, whereas, the temperature as recorded by Thermocouple #1, which was attached to the top mattress, and Thermocouple #3, which was fastened to the middle mattress, reached 230° F. in about one hour and 40 minutes. On the other hand, Thermocouple #2 placed inside the cotton-felt pillow and zippered shut, and Thermocouple #4, fastened to the bottom mattress, failed to reach the desired temperature of 230° F. at the end of three hours exposure

In Test II, in which formaldehyde was used in addition to dry heat, and conducted 30 minutes after Test I, the temperature recording chart registered 230° F. in 51 minutes. Thermocouples #1, #3, and #4 reached the desired temperature within an hour and a half. Thermocouple #2 which was inside the zippered cotton-felt pillow again did not reach 230° F. during the exposure period of two and one-half hours.

In Table I, the results of all the bacteriologic and temperature recording tests and relative humidity observations made during the second field survey are shown. The findings relative to the temperature rise and heat penetration inside a zippered cotton-felt pillow show that


Temp. °F
260
240
230
220
200
180
160
140
120
100
80
60
40
20
0
0 10 20 30 40 50 1 hr. 10 20 30 40 50 2 hr. 10 20 30 40 50 3 hr.
Time
Test 1
Recording Thermometer
Thermocouple no. 1
" " 2
" " 3
" " 4


260
240
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220
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160
140
120
100
80
60
40
20
0
Temp. °F
0
10
20
30
40
50
1 hr.
10
20
30
40
50
2 hr.
10
20
30
40
50
3 hr.
Time
Test 2
Recording Therm.
Thermocouple no. 1
" " 2
" " 3
" " 4

RESULTS OF BACTERIOLOGIC EXPOSURE TESTS AND

No. of Tests	Type of Test	Test Date	Exposure Period		Test Organisms										
					E. coli			A. cloacae			Ser. marcescens			Staph	
					Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	
		1951	Hrs.	Min.											
1	Dry Heat	7-30	2	00	3	0	3	3	0	3	3	0	3	3	
2	Dry Heat + Formaldehyde	7-30	1	15	5	0	5	5	0	5	5	0	5	5	
3	Carboxide	7-31 8-1	15	00	6	0	6	5	0	5	5	0	5	5	
4	Carboxide	8-1	6	00	5	0	5	5	0	5	5	0	5	5	
5	CO_2 + Et O	8-1 8-2	15	00	5	0	5	5	0	5	5	0	5	5	
6	CO_2 + Et O	8-2	6	00	5	2	3	5	0	5	5	0	5	5	
7	CO_2 + Et O	8-2 8-3	15	00	5	2	3	5	0	5	5	1	4	4	
8	CO_2 + Et O	8-3	2	30	4	3	1	4	0	4	4	4	0	4	
9	Formaldehyde	8-2 8-3	16	20	5	4	1	5	2	3	5	1	4	5	
10	CO_2 Alone	8-3 8-4	18	00	2	2	0	4	3	1	4	4	0	4	
11	Formaldehyde	8-9 8-10	15	30	-	-	-	1	0	1	3	2	1	1	

* Outside Temperature

TABLE I

RESULTS OF BACTERIOLOGIC EXPOSURE TESTS AND TEMPERATURE AND RELATIVE HUMIDITY RECORDINGS

Test Organisms																
coli		A. cloacae			Ser. marcescens			Staph. aureus			B. cereus			Myco. phlei			Quantities (Pounds)
	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed	
0	3	3	0	3	3	0	3	3	0	3	3	3	0	3	0	3	
0	5	5	0	5	5	0	5	5	0	5	5	5	0	5	2	3	
0	6	5	0	5	5	0	5	5	0	5	5	5	0	5	0	5	3.65/100 cu. ft. 13.5
0	5	5	0	5	5	0	5	5	1	4	5	5	0	5	0	5	3.65/100 cu. ft. 13.5
0	5	5	0	5	5	0	5	5	0	5	5	5	0	5	0	5	12 CO_2 1 Et $_2O$
2	3	5	0	5	5	0	5	5	0	5	5	5	0	5	1	4	12 CO_2 1 Et $_2O$
2	3	5	0	5	5	1	4	4	1	3	5	5	0	5	3	2	1/2 Et O 6 CO_2
2	1	4	0	4	4	4	0	4	1	3	4	4	0	4	2	2	12 CO_2 1 Et $_2O$
2	1	5	2	3	5	1	4	5	1	4	5	5	0	5	2	3	1/2 HCHO 1/4 $KMnO_4$
2	0	4	3	1	4	4	0	4	4	0	4	4	0	4	4	0	12
2	-	1	0	1	3	2	1	1	0	1	1	1	0	1	1	0	1/2 HCHO 1/4 $KMnO_4$

RELATIVE HUMIDITY RECORDINGS

cereus		Myco. phlei			Quantities (Pounds)	Temperature Inside Chamber			Relative Humidity
Number Cultures Survived	Number Cultures Killed	Number Cultures Exposed	Number Cultures Survived	Number Cultures Killed		Before Exposure	During Exposure	After Exposure	
3	0	3	0	3		84° F	90° F	90°+ F	70±
5	0	5	2	3		94°	94°	94°+	52±
5	0	5	0	5	3.65/100 cu. ft. 13.5	86°	80°-88°	88°-80°	81.5-100±
5	0	5	0	5	3.65/100 cu. ft. 13.5	80°-81°	80°-92°	92°-84°	58±
5	0	5	0	5	12 CO_2 1 Et $_2O$	84°- 86°	93°-80°	89°-78°	46±
5	0	5	1	4	12 CO_2 1 Et $_2O$	76°-78°	80°-92°	84°-92°	60±
5	0	5	3	2	1/2 Et O 6 CO_2	84°-86°	81°-90°	90°-80°	72±+
4	0	4	2	2	12 CO_2 1 Et $_2O$	80°-82°	80°-90°	86°-90°	73±
5	0	5	2	3	1/2 HCHO 1/4 $KMnO_4$	84°			53±
4	0	4	4	0	12	84°-86°	90°-88°	88°-79°	52±
1	0	1	1	0	1/2 HCHO 1/4 $KMnO_4$	86°	80°-85°	75°	64+ 66±

in the dry-heat test all the test organisms exposed for two hours were killed except B. cereus, a sporulating organism. The bacteriologic results of the dry-heat and formaldehyde tests were about the same as those found with dry heat alone. It should be noted that the temperature (230°F.) shown on the recording thermometer outside the chamber was not reached in some of the mattresses. Further studies with this sterilizing process were needed for confirmation.

Ethylene Oxide and Carboxide* Tests. The purpose of the study at the Goodwill Industries plant in Indianapolis was to test the efficiency of ethylene oxide and Carboxide as sterilizing agents. The Goodwill Industries of Indianapolis had installed a steel, gas-tight chamber in which such chemical gases as methyl bromide, ethylene oxide, Carboxide, etc., could be employed in the sterilization of used bedding, furniture, and other articles. The steel chamber was a nonvacuum or low-pressure type built to withstand an internal pressure of two pounds per square inch. The size of the chamber was 5'7" x 5'8" x 10'5", and had a capacity of 330 cubic feet.

*Carboxide: A mixture of gases containing one part ethylene oxide to nine parts of carbon dioxide.

The sterilizing agents introduced into the chamber consisted of (1) carbon dioxide followed by ethylene oxide (final mixtures 12 lbs. CO_2 to 1 lb. ethylene oxide and six lbs. CO_2 to 1/2 lb. ethylene oxide per 330 cu. ft.), (2) Carboxide, and, (3) carbon dioxide alone as a control. Exposure periods to these agents ranged from two and one-half hours to fifteen hours. An interval of 30 to 45 minutes usually elapsed between each exposure period during which time the inside of the chamber was exposed to the atmosphere. This period of time was considered sufficient to flush out any residual gas before the next test was started. The concentrations of ethylene oxide employed in the tests ranged from 0.5 (0.15 lbs./100 cu. ft.) to 1.0 lbs./330 cu. ft. (0.33 lbs./100 cu. ft.). Temperatures inside the chamber were automatically recorded before, during, and after each exposure period. Relative humidity readings were also taken and recorded before and after each exposure period.

Filter paper strips, enclosed in sterile paper envelopes, were placed on mattresses, so that they would be exposed to representative locations inside the chamber after the loaded cart had been rolled in, and the chamber sealed. The exposed filter paper strips were taken to the Indiana State Health Laboratories, placed in culture tubes containing tryptose-phosphate broth and incubated. Tubes showing growth within two-weeks' incubation time were examined. All negative tubes were assumed to indicate that the test organism had been killed by the sterilizing agents. For controls, unexposed strips of filter paper containing the dried test

organisms, were placed in culture tubes and incubated. In all cases the control tubes contained the growth of the organisms originally impregnated onto the filter paper strips. This was confirmed by microscopic examination of the positive tubes.

Procedures employed in the Carboxide tests. A large cylinder of Carboxide was placed on scales located beside the chamber. The cylinder was then attached to the chamber control valve by metal tubing. The weight of the cylinder was recorded, and the scales set to 12 lbs. less than the weight of the cylinder. The sterile paper envelopes containing the filter paper strips were placed on the mattresses, and the cart rolled into the chamber. The door of the chamber was closed, and the temperature-recording instruments placed in operation. The chamber was initially flushed with Carboxide, flushed out, and the process was repeated a few times until it was felt that most of the original chamber air had been replaced. The exhaust chamber valves were closed and the Carboxide was allowed to enter the chamber until the scales were balanced at the 12 lbs. less than the original weight of the Carboxide cylinder. It was estimated that this amount would produce an atmosphere within the chamber of 3.65 lbs. Carboxide/100 cu. ft. This concentration of Carboxide apparently was not reached, since studies at Camp Detrick have shown that when 30 lbs. of Carboxide were introduced into a chamber, only 30 to 40% remained after the required flushing. On the basis of the 3.65 lbs. of

Carboxide per 100 cu. ft. introduced into the chamber calculations showed that if a minimum of 30% of the carboxide remained in the chamber after flushing, the concentration would be approximately 1.0 lb./100 cu. ft.

Procedures employed in the ethylene oxide and carbon dioxide tests. In these tests, a large carbon dioxide cylinder was placed on the scales and weighed. The scales were then set to balance at a point less than the original weight of the cylinder according to the type of test being conducted. For example, three tests were made in which 12 lbs. of carbon dioxide and one pound of ethylene oxide were employed, and one test in which 6 lbs. of carbon dioxide and a half pound of ethylene oxide were employed, thus, the scales were set at 12 lbs. less than the original cylinder weight for the first three tests, and 6 lbs. less the cylinder weight for the latter test. The filter paper strips in their envelopes were placed on the mattresses as before, the cart rolled into the chamber, and the door sealed. The carbon dioxide was allowed to enter the chamber until about one pound of internal pressure was shown on the pressure gauge attached to the chamber. The cylinder valve was closed, and the chamber exhaust valve opened slightly to allow the air-carbon dioxide mixture to escape until the pressure gauge indicated zero. This procedure was repeated several times, the exhaust valve closed, and the carbon dioxide allowed to enter the chamber until the scales balanced as before. The cylinder inlet valve was closed at this time.

One pound cans of liquid ethylene oxide were then attached to a can-puncturing device located on top of the chamber, and the ethylene oxide allowed to flow into a shallow pan previously placed near the top, inside the chamber where an inlet tube entered. Following the release of all the ethylene oxide, the blower fan inside the chamber was turned on and kept in operation throughout the process. Temperature records were made during the exposure periods. Following each exposure period, the exposed filter paper strips in their respective envelopes were examined microbiologically as described previously.

Two additional tests using formaldehyde were conducted in Muncie, Indiana. The procedures employed were similar to those conducted during Survey No. I. The exposure periods for these two tests were 16 hours and 20 minutes and 15 hours and 30 minutes, respectively. Temperature and relative humidity readings inside the chamber were made.

Results

1. Carboxide tests.

   a. Carboxide at approximately 1.0 lb./100 cu. ft. for a 15 hour exposure period was fairly effective against all the test organisms, except for the sporulate, B. cereus.

   b. Carboxide at the same concentration for a 6-hour exposure period was not as effective since one of the other test organisms in addition to B. cereus survived.

2. Ethylene oxide and carbon dioxide tests.

   a. Ethylene oxide and carbon dioxide, applied separately in quantities of 1.0 lb. ethylene oxide to 12 lbs. carbon dioxide/330 cu. ft., were effective for the 15-hour exposure period, but less effective in the six and two and one-half-hour exposure periods.

   b. Ethylene oxide and carbon dioxide applied separately in quantities of one-half pound ethylene oxide to 6 lbs. carbon dioxide/330 cu. ft. for 15 hours were as effective as formaldehyde.

3. Carbon dioxide alone.

   a. Carbon dioxide per se has no effect as a sterilizing agent.

4. Formaldehyde tests.

   a. The results of the formaldehyde tests indicate again that this agent was ineffective.

The findings indicate that a minimum of 15 hours exposure to either Carboxide at approximately 1.0 lb./100 cu. ft. or ethylene oxide and carbon dioxide (1.0 lb. ethylene oxide to 12 lbs. carbon dioxide/330 cu. ft.) is necessary to kill all the organisms present in the test materials, except the sporulating species.

Recommendations for Future Activities of the Subcommittee.

The following recommendations for future activities of the Subcommittee are proposed for consideration. These recommendations are based on the findings of the field studies and as a result of a Subcommittee meeting held on April 16, 1952 at the Environmental Health Center, Cincinnati, Ohio.

1. In view of the results of the dry-heat study, it was recommended that additional experimental work be continued. It was suggested that this work include tests at temperatures higher than 230° F. for various exposure periods, in order to demonstrate the killing of pathogenic, spore-forming bacteria.

Although it has been established that the dry-heat process is injurious to upholstered furniture, comments received from some of the Subcommittee members indicate that operating costs and time factors justify the use of this method for the sterilization of used bedding and bedding materials.

2. Recommendations were made to continue the studies on dry-heat and formaldehyde.

Since studies have shown that formaldehyde may remain in bedding materials up to 34 days after sterilization, the residual effects of formaldehyde as a health hazard were questioned. The opinion of the Subcommittee members in this respect was that the

concentrations of formaldehyde remaining in bedding and bedding materials following sterilization would not be of sufficient toxicity to create any serious health hazard.

3. It was suggested that in view of the results of the tests in which formaldehyde alone was used as the sterilizing agent at atmospheric pressure, further consideration of this agent should be eliminated.

4. Further investigations of new sterilizing agents and new methods of sterilization should be conducted. At the present time, the application of ethylene oxide or Carboxide is being emphasized because of its effectiveness as a sterilizing agent and its simplicity and safety of operation. This agent can be easily released into a gas-tight chamber and held there for an indefinite time.

The introduction of carbon dioxide followed by ethylene oxide into a chamber rather than Carboxide was particularly favored. The proper amounts of each material can be released into a chamber in sufficient quantities so as to maintain an adequate, sterilizing concentration without fear of excessive internal pressure and little, if any, loss of the ethylene oxide.

It was shown that this method would be relatively economical as compared to the use of Carboxide. For example, the relative costs including delivery and return of CO_2 and ethylene oxide cylinders, rental, etc., as compared to Carboxide cylinders are as follows:

CO_2 ---------- 6¢ to 8¢ per pound
Carboxide ---------- 30¢ to 35¢ per pound
Ethylene oxide ----------$1.50 - $2.00 per pound in 1/2 lb. disposable cans

The comparative costs of these agents based on the concentrations (1 lb. ethylene oxide and 12 lbs. CO_2/330 cu. ft., or 12 lbs. Carboxide) employed in the field studies are:

Carboxide - 12 lbs. at 30¢ = $3.60

Ethylene Oxide - 1 lb. = 2.00)
) $2.72
Carbon Dioxide - 12 lbs. at 6¢ = .72)

This shows a saving of 88¢ per exposure if the ethylene oxide and carbon dioxide are applied separately.

It was finally recommended that since the ethylene oxide and CO_2 and the Carboxide tests did not show complete sterilization, additional studies should be made to:

a. Investigate the effects of ethylene oxide at temperatures of 100° F. or above.

b. Investigate the effects of ethylene oxide at higher concentrations with various exposure periods. Studies at the Chemical Corps Biological Laboratories, Camp Detrick, Frederick, Maryland, have demonstrated that sterilization can be obtained with about 3 lbs. of ethylene oxide/100 cu. ft. in 6 - 12 hours, depending on the temperature and compactness of materials.

c. Investigate the extent of leakage of ethylene oxide from chambers in order to determine the quantity maintained within the chamber during each exposure. This can be accomplished by chemical analysis of the air during the exposure period.

d. Investigate the effects of ethylene oxide in a pressure chamber.

5. Until experimental results indicate otherwise, it was recommended that the following tentative list of methods may be used in most any institution where sterilization of materials is a necessary part of their operation.

I. Sterilization methods.

A. Heat processing methods.

1. Autoclave sterilization with saturated steam at 250° F. (121° C.).

B. Chemical methods.

1. Chamber sterilization with ethylene oxide or Carboxide.

In addition to the foregoing recommendations, suggestions were presented for consideration at the April 16, 1952 meeting relative to the long-range objectives of the Subcommittee. These are as follows:

1. Consideration should be given to the future design of processing chambers in relation to their construction with a door in each end of the chamber. This arrangement is provided so that processed materials can be removed directly into a storage room for sterilized materials without contact with unprocessed materials in any way.

2. It was the unanimous opinion of the members present at the Subcommittee meeting that emphasis be placed on methods which will insure complete sterility of the materials processed, i.e., methods which will destroy all forms of living matter. This decision resulted from the fact that in order to insure the destruction of such organisms as: (a) enteric pathogens (Salmonella and Shigella), (b) Mycobacteria, (c) viruses, (d) pathogenic spore-formers (Clostridium tetani, and welchii, and Bacillus anthracis), (e) respiratory pathogens, (f) rickettsia, and (g) pathogenic fungi, complete sterilization is necessary.

3. Consideration should be given to the order in which laundrying, shampooing, or dry cleaning of used bedding materials is conducted in relation to the sterilization processes in order to protect the health of the workers handling such materials.

This report summarizes the results of the field surveys, and the recommendations of the Subcommittee.

Respectfully submitted,

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Subcommittee on the Development and/or Standardization of Methods for the Sterilization of Bedding, Bedding Materials and Upholstered Furniture.

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